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Complementary Concepts on the Effects of Sound on Consciousness

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Abstract

The beneficial use of sound vibration has its precedent in thousands of years of history. From primitive times to the present, sonic vibration in the form of music, voice, drumming, and many other modes has been recognized as having powerful effects on the mind and body. Modern medical technology employs ultrasound. Natural sounds support meditation and promote healing. Music changes moods and states of consciousness. Binaural beats generate propitious states of consciousness. The powerful sonic vibrations produced by dolphins have been measured and reportedly stimulate profound changes in body and mind.

Western scientific methodology has always stressed the need to understand the underlying mechanisms behind the apparent effects of all these applications. There is now some empirical scientific data available demonstrating the mediating effects sound has on consciousness and the physical body. These conventional investigative measures may, however, be inadequate. Emerging fields of research such as the study of electromagnetic bioenergy fields or a return to the traditional notion that consciousness is somehow mediated by the cerebrospinal fluid in the brain's ventricles and spinal column may be more apropos.

Introduction

For thousands of years cultures around the world have recognized that sonic vibrations influence states of consciousness and the physical body. Primitive peoples used music, rhythmic drumming, and chanting in religious practices as a means of restoring or maintaining wellness. Shamanic, Chinese, Indian, Islamic, Hebrew, Egyptian, and Greek cultures all used sound vibration to induce altered mental states and to heal the sick. Pythagoras encouraged the use of specific sounds to clear the mind and inspire, others to soothe and relax, and still others to cure the body and spirit. Plato and Aristotle taught that sound and music were curative. In more recent times, classical and romantic composers saw music as a powerful means of influencing consciousness (Williams 1993). These same composers thought they would be responsible for the evolution of civilization through their music. As we approach the 21st century, auditory stimulation is widely accepted as a means of altering mood state and consciousness as well as affecting the physical body and modern research bears out the connection between music and healing (Poole 1993).

Therapeutic and Beneficial Consciousness-Altering Uses of Sound Vibrations

The modern therapeutic use of sound vibration includes many different *treatment* concepts. Chiropractors, osteopaths, and physical therapists apply ultrasound, a high-frequency penetrating sound, to injured areas of the body to increase blood flow and to promote the healing process itself. As a diagnostic tool, ultrasound is also used in medicine to image internal physical structures. Some forms of ultrasound are used as an alternative to invasive therapy, to destroy cataracts, kidney stones and gallstones, and even some kinds of tumors (Cochrane & Callen 1992). Various "natural sounds" such as drumming, ringing bowls, wind and surf, flowing water, rain and animal sounds like birdsong, crickets, purring, heartbeat, humming and singing, etc., have all been applied to support meditation and/or promote healing processes. In a therapeutic technique called Resonant Kinesiology, the human voice is used as a stimulus in conjunction with movement and touch as an integrated component in a focused intent to heal (Bacon 1992). This multiple-stimuli approach with an integrated singular intent my be akin to the *Theory of Sensory Resonance* (Estes 1995), in which multiple stimuli that are resonant with each other are said to be effective because of their impact on the reticular activating system. Different musical themes are known to affect mood state and consciousness and have been used in a wide range of applications from enhancing learning and memory to stimulating immune system functioning. There is an ancient link between music and health. Music directly influences heart rate, breathing, and contraction of the stomach (Poole 1993).

Binaural beating, an inner-cranial auditory phenomenon, promotes propitious states of consciousness and has a wide variety of applications (Atwater 1995). Owens and Atwater (1995) report that listening to binaural beats has different effects depending on the frequency of the binaural-beat stimulation. Binaural beats in the delta (1 to 4 Hz) and theta (4 to 8 Hz) ranges are associated with reports of creativity (Hiew 1995), sensory integration (Morris 1990), relaxed or meditative states, or as an aid to falling asleep (Wilson 1990; Rhodes 1993). Binaural beats in the beta frequencies (typically 16 to 24 Hz) are associated with reports of increased concentration or alertness (Monroe 1985) and enhanced-memory function (Kennerly 1994).

Organizations involved in dolphin-assisted therapy regularly report direct improvements to the well-being of their patients as a result of participation in their interactive programs (Cole 1994). When dolphin-assisted therapy involves in-the-water participation with a dolphin, the sonic vibrations produced by the dolphin not only leave the human body virtually transparent to the dolphin (as in a medical ultrasound) but reportedly affect mood, consciousness, and physical wellness. Although some proponents of dolphin-assisted therapy only attribute the dolphin with the ability to psychologically affect a patient or serve as a distraction mechanism, others feel that swimming with dolphins can also have a profound physiological effect (Blow 1995). This physical effect is believed to be directly related to the sounds used by the dolphins to perceive and interact with their environment. Individuals with such ailments as Down's syndrome, autism, depression, attention deficit disorder, chronic fatigue syndrome, muscular dystrophy, and spinal cord injuries have all benefited from dolphin-assisted therapy (Cole 1994; Cochrane & Callen 1992).

Objective Measurement of Sound's Effects

Western scientific methodology stresses the necessity to understand the underlying mechanisms behind the apparent effects of all these applications. The observed benefit of these interventions may be inappropriately attributed to the sound stimulus itself. Conversely, if the sound stimulus can scientifically be shown to be responsible for the observed effects, then perhaps these same propitious effects could be enhanced through practical application of this knowledge.

This short review addresses only some of the empirical scientific data available demonstrating sound's mediating effects on consciousness and the physical body. These include objective brain-wave data, recorded physiological information, and subjective reports. The discussion here is limited to three areas of inquiry: resonant kinesiology, binaural-beat stimulus, and dolphin-assisted therapy. The discussion is additionally somewhat limited in focus to the objective data that have been collected regarding the mediation of conscious states engendered by these stimuli.

Resonant Kinesiology

On November 19, 1993, a laboratory investigation of "Cell Singing," a form of Resonant Kinesiology (see Bacon 1992), was conducted (Atwater 1994). This investigation was carried out with the intent of examining EEG and other physiological parameters of a single subject, DW, in conjunction with the activities of LC, a massage therapist who practices an alternative technique that she calls Cell Singing. Cell Singing involves toning or singing notes directly over or adjacent to various parts of the physical body.

For the laboratory investigation, we wanted to make a record of EEG brain-wave data and certain physiological responses of the subject, DW, during various behaviors performed by LC. No instrumented monitoring of LC was conducted but she was under the observation of a physician during the entire course of the investigation. The Cell Singing was performed on DW while he was while lying supine on a waterbed in an isolated, shielded environment. DW was connected to a 20-channel computerized EEG (Neurosearch-24, LEXICOR, Boulder, Colorado) using V151 software and a J&J physiological monitoring system using an I-330 interface and

software with a T-601 temperature module for measuring peripheral skin temperature, a T-601 electrodermograph module for measuring galvanic skin response, and an A-101 direct current (DC) amplifier module for measuring skin potential voltage.

Peripheral skin temperature declined slightly during the evaluation. This was not considered a significant change. It does mean that DW did not experience a physical body relaxation response to the Cell Singing process. Galvanic skin conductance decreased (increased resistance) during the evaluation. This indicates that DW experienced a reduced level of emotional arousal during the process. Recorded DC skin potential voltage changes were attributable to the variation in skin resistance and did not provide further insight.

During the Cell Singing trial period DW's resting-state-alpha was suppressed an average of 35% when compared to baseline. The importance of this in relation to Cell Singing remains unknown. Detailed examination of the trial-period gamma activity in the left LCC quadrant revealed the presence of non-artifact amplitude spikes associated with specific areas of DW's body being treated by the Cell Singing process. An unusual number of these significant gamma amplitude spikes occurred when DW's chest area was exposed to focused Cell Singing. (See Illustration 1.) The meaning of these gamma-amplitude spikes remains unknown. This finding warrants further study.

Illustration 1

During an interview after the testing process, DW reported feeling energized and refreshed following the Cell Singing treatment. He appeared animated and enthusiastic. DW said that he would like others to experience the process because it made him feel good.

Binaural-Beat Stimulus

Auditory binaural beats occur when two pure tones (sine waves) of nearly similar frequencies are presented, one to each ear. The brain detects phase differences between these signals. This phase difference normally provides directional information to the listener but when presented with stereo headphones or speakers the brain processes this anomalous information differently. Under these circumstances a perceptual integration of the two signals takes place, producing the sensation of a third sound called a binaural beat. The binaural beat is perceived as a fluctuating rhythm at the frequency of the difference between the two (stereo left and right) auditory inputs. Evidence suggests that binaural beats are generated in the brainstem's superior olivary nucleus, the first site of contralateral integration in the auditory system (Oster 1973).

Owens and Atwater (1995) examined EEG patterns associated with listening to a series of low-frequency binaural beats and investigated some of the subjective experiences accompanying such stimulation. In this study, subjects listened through stereo headphones to pure tones designed to produce delta and theta binaural beats. Analysis of the EEG data involved computing the changes in the percentages of total EEG amplitudes, comparing the conditions of waking rest, binaural-beat stimulus periods, and a second period of rest. Results showed that during the stimulus periods subjects generated significantly less alpha- ($p < .01$ to $p < .0001$) and beta- ($p < .04$ to $p < .002$) frequency brain waves and significantly more delta- ($p < .002$ to $p < .0009$) and theta- ($p < .01$ to $p < .0001$) frequency brain waves. Subjects reported that

their subjective awareness was akin to a trance, meditative, or prolonged-hypnagogic state. This investigation suggested that low-frequency binaural beats may be associated with reduced EEG arousal and with altered states of consciousness.

Much speculation surrounds the possible mechanisms underling these psychophysiological state changes. Studies have demonstrated the presence of an EEG frequency-following response to auditory stimuli recorded at the vertex of the human scalp (Smith, Marsh, & Brown 1975; Marsh, Brown & Smith 1975; Smith et al. 1978; Hink et al. 1980). It may be that sufficient exposure (amplitude, duration, and frequency) to auditory stimuli may influence brain waves to the point of altering prevailing EEG (and, therefore, associated subjective states) through the mechanism of this frequency-following response. This possible mechanism could be viewed neurologically as a process of resonant entrainment of oscillating systems, a well-understood principle within the physical sciences (Atwater 1995). Alternatively (perhaps additionally), the perceptual experience of binaural beats could be seen as a psychologically "disruptive force" or "patterning force" required in the induction of a discrete altered state of consciousness (Tart 1975). Binaural beats also affect the reticular activating system through traditional neural pathways. In addition to their main paths to the cerebral cortex, sensory nerves route branch lines through the reticular formation. The reticular formation then alters the electrical potentials of the cerebral cortex (measurable by EEG), arousing or quieting this so-called higher center of the brain (The Diagram Group 1982).

There have been several *free-running* EEG studies (Owens & Atwater 1995; Hiew 1995; Foster 1990; Sadigh 1990) which suggest that the frequency-following response to binaural beats may induce alterations in EEG. There have also been numerous anecdotal reports of state changes (alterations in consciousness) encouraged by various low-frequency binaural beats (Monroe 1985). However, a frequency-following response to binaural beats in frequency ranges associated with these states has yet to be demonstrated using apropos *evoked-potential* EEG protocols. The frequency-following response is not revealed under the conditions of a *free-running* EEG recording. The amplitude of the frequency-following response relative to the ongoing EEG is so low that it can only be revealed using *evoked-potential* EEG protocols employing time-domain averaging of the stimulus periods. Previous *free-running* EEG studies have assumed that prolonged exposure to binaural-beat stimuli influenced brain waves to the point of altering ongoing EEG through entrainment of the frequency-following response – a theorized process of nonlinear stochastic resonance.

The Monroe Institute recently conducted a pilot study using multiple-subject trials (N = 7) designed to objectively verify a frequency-following response to theta and beta binaural-beat stimuli through the use of an appropriate *evoked-potential* protocol. This study was designed to determine if a 7 Hz (theta) binaural beat would engender a 7 Hz-EEG response and if a 16 Hz (beta) binaural beat would engender a 16 Hz-EEG response.

The hypothesis of this pilot study postulated that subjects exposed to binaural-beat stimuli would evidence increases in amplitude of time-domain averaged EEG in frequencies matching binaural-beat stimuli when compared to a silence-baseline condition. Elevation in EEG amplitude (an arousal response) could be expected in the case of a carrier-tone stimulus without a binaural beat. Significant increases in 7 Hz- and 16 Hz-EEG amplitudes during

comparable binaural-beat stimuli periods over the silence-baseline condition would imply the development of a frequency-following response to binaural-beat stimuli.

To control for subject expectation, an eighteen-episode Latin-Square protocol which provided two seconds of a binaural-beat stimulus at 7 Hz, 16 Hz, and two seconds of a carrier tone (without a binaural beat) was used. Between each two-second stimulus interval were two seconds of silence. The onset pulses were reversed in the middle of the protocol so as to phase-cancel the gross brainstem response, the evoked potential of the tones themselves (vs. the binaural-beat component). The entire test sequence lasted about thirty-five minutes.

Preliminary EEG signal analyses consisted of 1) the analog-to-digital conversion of the raw brain waves; 2) editing the digitized EEG; 3) extracting, ordering, and phase aligning one-second binaural-beat stimuli, carrier-tone, and silence-baseline epochs; 4) time-domain averaging 180 one-second (256 sample integer array) epochs of each stimulus condition, and 5) performing Fast-Fourier Transform (FFT) of the time-domain averaged data. Results of FFT computation yielded amplitude values in microvolts for the brain-wave frequencies of interest. Individual subject trials were then averaged together.

Statistical analysis consisted of using averaged FFT values for each test condition. Comparisons between the binaural-beat stimuli periods and the silence-baseline condition were made with single-sample t-tests. The results of this analysis were as follows:

7 Hz Stimulus » Silence Baseline			
Mean = 0.069	S.D. = 0.040	t = -6.80	p = < .001 (2 - sided)
16 Hz Stimulus » Silence Baseline			
Mean = 0.033	S.D. = 0.021	t = -4.04	p = .007 (2 - sided)

The table above depicts significant EEG amplitude increases during frequency-appropriate binaural-beat stimuli periods over the silence-baseline condition. This implies the development of a frequency-following response to the 7 Hz and 16 Hz binaural-beat stimuli. The chart in Illustration 2 shows the anticipated arousal response to the carrier-tone stimulus and the substantial EEG amplitude increases in 7 Hz and 16 Hz during the appropriate binaural-beat stimuli periods over the silence-baseline condition – *the frequency-following response*. Based on the findings of this pilot study, a university-level formal study is under consideration.

Illustration 2

A great deal of research has been conducted concerning the frequency, amplitude, band width, and duration of the sonic emanations of the dolphin. These data are available elsewhere and are not the subject of this presentation (see Cochrane & Callen 1992) . There has even been some interesting work done in an attempt to communicate with dolphins (Cochrane & Callen 1992). As stated before, when dolphin-assisted therapy involves in-the-water participation, people experience mood shifts, alterations in consciousness states, and the healing of physical ailments. Dolphins seem to emit special energy and sound vibrations that can have a potent influence on body, mind, and spirit (Cochrane & Callen 1992). Sound appears to be a discriminating component of the dolphin experience. Yet, the effect that this obvious element may have on the human mind and body continues, for the most part, to be studied very little. Cochrane and Callen (1992) believe that the whistles and squeaks that the dolphin emits may contribute to the healing phenomenon, by virtue of their influence on human emotions, in a similar way to music therapy.

Several years ago research at the AquaThought Foundation (see Cole 1994) began to reveal some objective information that may be of value in understanding some of the psychophysiological effects of this seemingly obvious component of dolphin-assisted therapy. Brain-wave research from the AquaThought foundation revealed that a subject's dominate brain-wave frequency drops significantly after a dolphin interaction. Hemispheric synchronization was also apparent after the dolphin interaction. What was missing from this research was the ability to record dolphin sounds and correlate them to simultaneously observed biophysical data -- not an easy thing to do.

Birch and Cosic (1995) have reported on the development of a system for monitoring dolphin sonar emissions using a small hydrophone connected to a float and then digitally linked to a microprocessor. This system, however, did not provide for the monitoring of human physiology during dolphin interaction.

Rollings and Byrd (1995) have reported on an extensive project called *Hello, Dolphin* by World Dolphin Research that attempts to simultaneously measure acoustic, electric, electrostatic, and magnetic signals emanating from dolphins during human-dolphin interaction. Human brain-wave data were collected before and after encounters. Rollings and Byrd (1995) felt that preliminary data suggested attempts by dolphins to communicate with humans in certain frequency ranges.

There continue to be several ongoing projects measuring chemical changes presumed associated with dolphin interaction (Cole 1995). As with all these projects, the mechanism by which mental states and physical properties are changed remains elusive. Cole (1994) offers sono-chemistry as an explanation for changes observed as a direct result of a dolphin's echolocation output. Sono-chemistry is described as the interaction of sound with matter through the process of cavitation[1]. Some have suggested that dolphin echolocation may cause neuronal migration and other cellular changes in living tissue (Cole 1995). Cole has written that sono-chemistry may explain both the chemical and electrical changes observed in the brain and presumed to be the result of dolphin-human interface (Cole 1995). Estes (1995) has set forth a

[1] Researchers induce cavitation using intense sound waves that create alternating regions of compression and expansion that can form bubbles 100 microns in diameter.

Theory of Sensory Resonance that may lead to an understanding of the elusive mechanism by which mental states and physical properties are changed as a result of dolphin-human interface. This theory focuses on the well-understood functions of the brain's reticular activating system. This unique system controls arousal, attention, and awareness (Tice & Steinberg 1989). The word *reticular* means "net-like" and the neural reticular formation itself is a net-like system of circuits running from the middle of the brainstem to the cerebrum. It is a large, diffuse area of the brainstem (Anch et al. 1988). If it can be shown that the sound stimulation experienced during dolphin-human interface affects the reticular formation in some direct manner, it would go a long way towards explaining how mood changes, states of consciousness transform, and healing occurs.

Reaching Beyond Our Present Understanding

In our attempts to understand the underlying mechanisms behind the apparent effects of sound stimulus, we may have to extend our investigations into emerging, speculative areas of science. Reaching beyond the limitations of EEG, GSR, and other traditional monitoring equipment will possibly open our investigations to some criticism but this may be the best way to obtain data relevant to the observed changes in mental states and physical wellness we are observing. These emerging technologies show great promise in revealing the underlying mechanism behind the apparent mediating effects of many forms of propitious stimuli including Resonant Kinesiology, the binaural beats of the Hemi-Sync[2] process, and the sound component of the dolphin-human interface.

Measuring Electromagnetic Bioenergy Fields

Hunt (1995) has reported on the twenty-year development of a scientific method for monitoring the electromagnetic bioenergy field that may be relevant to measuring consciousness states. In her book, *Infinite Mind*, she writes, "The electromagnetic component of the human energy field can be detected with special instruments . . ." (Hunt 1995). Conventional electrodes were attached to the skin at designated locations and the millivoltage frequencies from 500 Hz to 20 KHz were monitored. Frequency patterns were analyzed and categorized. Arousal, attention, awareness, mood, pain, and wellness were all detectable and had different frequency signatures. The pain signal, for example, has an approximate central frequency of 500 Hz (Hunt 1995) and an identifiable shape (see Illustration 3). In response to sensory stimuli (including sound) the energy field sometimes responded even when the person experienced no conscious sensation. Even more dramatic, changes occurred in the energy field before changes in brain waves, blood pressure, galvanic skin response, heartbeat, or muscle contraction (Hunt 1995). When data from two electrode locations were compared, a cross-plot analysis technique was used to determine the coherence of the two inputs. A measure of anti-coherency between the two signals was associated with physical and emotional dysfunction or disease (Hunt 1995).

Mental, emotional, and physical disease as well as degree of arousal, focus of attention,

Illustration 3

[2] Hemi-Sync®, a patented, state-of-the-art, auditory-guidance technology encourages access to beneficial states of consciousness. In addition to verbal instructions, this auditory-guidance process involves carefully constructed blends and sequences of sound patterns and binaural beats designed to evoke propitious brain-wave states.

and level of awareness become obvious in these energy-field measurements. Hunt's research speculates that disease (and healing) begins in the energy field which is generated at the atomic level and then manifests progressively in the molecular, cellular, and system levels. If dolphins can sense imbalance in the human energy field, perhaps it can be affected by sympathetic resonance with similar force fields (Cochrane & Callen 1992). Work at World Dolphin Research (see Rollings & Byrd 1995) is sensitive to varied electromagnetic environment of the dolphin-human interface. The well-understood principles of resonant entrainment suggest that the human energy field be affected by such a rich environment. If what Hunt (1995) speculates is true about consciousness being mediated by and healing beginning in the energy field, then the effect that the dolphin-human interface has on the human energy field may be the key to understanding the mechanism behind observed changes in mood state, in consciousness, and in health. It would also be interesting to see what energy-field patterns develop in response to Cell Singing and binaural beats.

The Mediating Characteristics of Cerebrospinal Fluid

"The most dynamic frontier in science right now is a long-delayed effort to deal with the strangest stuff around." In this quotation Marilyn Ferguson (1996) refers to water. "When considering the potential healing effect of human and dolphin interaction, we cannot ignore that there is a powerful medium involved – water. Many proponents of the healing dolphin theory believe that water is just as important in the healing process as the dolphins themselves." (Cochrane & Callen 1992)

Water and consciousness may be more closely linked. There is reason today to revisit the traditional notion that consciousness may be somehow mediated by the cerebro-spinal fluid in the brain's cavities, the ventricles (Ferguson 1996). Cerebrospinal fluid is a water-based, nutrient-filled liquid generated within the two largest ventricles, the lateral ventricles. Each hemisphere of the brain contains one of these lateral ventricles. These fluid-filled cavities then connect with a centrally located third and fourth ventricle. These connect to the spinal column. Cerebrospinal fluid circulates freely around the brain and throughout these cavities. (See Illustration 4.)

Optometrist Ray Gottlieb has theorized that the brain may use the principles underlying the physics of phase-conjugate mirrors (from laser holography) to retrieve associated information and make decisions (Ferguson 1996). To Gottlieb and others, the brain's ventricles, filled with cerebrospinal fluid, provide the reactive medium needed to support such a theory. Other research shows that biological structures emit the photons providing the necessary light source for such a function (Rubik 1996). If, as Gottlieb speculates, the brain uses phase-conjugate principles, information could be distributed throughout the brain and body by means other than nerve pathways. Information may also be stored in cerebrospinal fluid in the same manner that water has been shown to have *memory*. Gottlieb's theory, although highly speculative, supports the holographic brain model proposed by Karl Pribram in the 1970's.

Illustration 4

Water (cerebrospinal fluid) surrounds the brain and many crucial, strategic neurological structures line the ventricles. (See illustration 5.) That this medium is critical to mental functioning is evidenced in individuals with enlarged ventricles who function intelligently with a minute fraction of the cortex of a normal brain. More than half of those with enlarged ventricles who have lost 95 percent of their cortex test above-average in intelligence. Apart from Gottlieb's somewhat radical hypothesis of brain function, the human body itself is said to be over 80 percent water.

The water in the body and encircling the structures of the brain is a wonderful conductor of only one band of electromagnetic energy: *sound*. It seems apparent from the discussions above that sound vibrations influence the human condition. It is also obvious that in addition to our ears and associated neural structures, water serves as a medium of transmission of this stimulus throughout the body and brain. By way of example, the function of the neurophone, invented by Patrick Flanagan in 1962, provides a mechanism for direct audio input to the brain (Cole 1994). Tony Bassett, an electrical engineer, discovered that sound frequencies near 2,000 Hz appear to trigger the production of endorphins in the brain (Cochrane & Callen 1992). Ultrasonic vibrations have a direct biological effect when used by medical practitioners as an alternative to invasive therapy. There seems little doubt that music, mechanically and naturally produced sounds, Cell Singing, Hemi-Sync, and dolphin echolocation produce physiological effects. This limited physiological approach does not, however, consider complementary effects sound may have on the mind and body.

Illustration 5

An *Informational* Theory

The informational content of the sound may be even more important than its direct physiological effects. The information content concept can be illustrated in several ways. In the

case of radio waves, we turn our radios to receive a 108 MHz station. The 108 MHz radio signal is modulated and it is this modulation that is the music and voice on the radio – the informational content. Another example is the voice. The sound frequencies of the human voice range from 400 Hz to about 3 KHz. These voice frequencies convey information. When we language-decode modulated voice we gain access to information. More subtly, we decode the voice signal and identify who is speaking, an additional piece of information. In a like manner, music conveys information. On the subtle level, each musical instrument has a characteristic wave shape. The electromagnetic sound frequency of 440 Hz (musically, the note A) is coded with the identity of its instrument of origin by the modulation of the 440 Hz sound wave. We know, through this information, if the sound we are listening to comes from a piano, a trumpet, or a violin. Beyond our ears, electromagnetic sound waves in the conducive medium of water in the body and surrounding brain and neural structures, may serve as carrier signals coded with information -- a pattern imprinted on the waves. In either case (traditional ear-linked neural pathways or via water conducted electromagnetic sound waves) the informational content of the sound becomes significant.

A logical progression from this line of thinking is that the sound energy that we have been discussing (from Cell Singing, Hemi-Sync, and dolphins), has more to it than brute electromagnetic force capable of changing physiological structures. It potentially contains information. In Cell Singing this information could come from the intent of the practitioner. Binaural beats in the Hemi-Sync process relay informational content in as much as they are carefully modeled after EEG brain waves. The dolphin's primary mode of communication is sound. Their sonar, therefore, must contain vast amounts of information as integral to this communication. The concept here is that the information content of these sounds subtly initiates (subtly, as in the recognition of someone's voice or the identification of a musical instrument) alterations in consciousness via the reticular activating system. How we interpret, respond, and react to information (both internal feelings, attitudes, and beliefs and external stimuli) is managed the brain's reticular formation.

Information-bearing electromagnetic sound energy, conducted via traditional neural pathways or through the cerebrospinal fluid (the reticular formation is located inside the brainstem adjacent to the fourth ventricle and is literally surrounded by water), interacts with the reticular formation and mediates the reticular activating system. Remembering that the reticular activating system controls arousal, attention, and awareness (the elements of consciousness itself), sound would seem to be able to influence consciousness by way of this informational mechanism. In objective, measurable terms the EEG provides evidence of this. The reticular activating system dictates the electromagnetic environment of brain function – *brain waves*. So, when brain waves are monitored, what is being measured in effect is the performance of the reticular activating system. The ability to measure and correlate brain waves with specific states of consciousness is a well-understood practice. Sound, therefore, has the ability to mediate consciousness, providing access to beneficial states of consciousness.

Concluding Comments

Sound may cause physiological changes in the body through the mechanism of Cole's sono-chemistry cavitation in the case of the dolphin ultrasonics or more subtly through resonant

entrainment in the cases of less-powerful dolphin sounds, Cell Singing, and binaural beating. Complementary influence on the performance of the reticular activating system and, therefore, consciousness may occur conventionally from traditional neuropathways, *informationally* from Gottlieb's phase-conjugate mirrors in brain ventricles or from Hunt's bioenergy fields, and dynamically from direct contact with electromagnetic sound waves in the cerebrospinal fluid in the ventricles. The dolphin communication concepts of Rollings and Byrd (1995) and the *Theory of Sensory Resonance* of Estes take on new significance from this perspective. The healing properties of sound are probably inclusive of both physiological influences and informational impetus providing healing-conducive states of consciousness.

Suggestions for continued scientific investigation to understand the underlying mechanisms behind the apparent effects of sound stimulus include the replication of existing work, refinement of monitoring methods to include the measurement of sound stimuli coincident with human response, and the inclusion of emerging fields of research. These emerging technologies offer new speculation on the mechanisms behind the physical and consciousness-altering effects of sound stimuli.

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